ACEEE Int. J. on Electrical and Power Engineering , Vol. 4, No. 2, Aug 2013

Transducer for Tension Force Measurement and Control of Fine-Winding Materials

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***Abstract*: - In this paper has been designed a facility (electromechanical system) for regulation the tension force of winding fine materials. In winding fine strip material such a thread it is important to get homogeneous density of the wound package, to get high quality material in next processing of this package. In order to achieve this goal, the designed facility controls the thread tension force during winding process and the driving motor speed. And it allows adjusting the tension force of the winding thread to the desired value, which is variable and depends on the radius of the package. This gives the required homogeneous density of the wound package material. The suggested facility consists of simple electronic circuit, lever, pulley, electromagnetic coils and other simple components. The suggested system is provided by an adjusting element in order to set the tension force of winding material at the required reference value.**

***Index Terms*: - Regulation, coil, tension force, speed control, fine material, lever.**

I. Introduction

In electric drive systems, which operate on winding tape or filament materials, such as thread, tape or paper, it is important to control mechanical forces [1, 2, 3, 4, 5, 6], because the winding-up materials are sensitive to these forces, particularly to the tension force [7] and to the change of moment of inertia [8]. Therefore, it is necessary to measure the tension force acting on the winding-up material. For measuring this tension force, electric drive systems use different types of sensors and transducers [2], [9], and [10], which usually have a sophisticated construction and require power supply [2] and [10].

Author in [11] is studying the basic requirements set forth for high-speed bobbin carriers, and describes the structure and operating principles of a high-speed friction bobbin carrier. The bobbin carrier developed can be used on high-speed molders, winders, rewinders, and thread-texturing machines on which the winder is placed in rotary motion by an axial drive.

But the friction bobbin carriers have the problem of slip between the bobbin and the driving friction cylinder. In the other hand, the non-frictional bobbin type of winding does not suffer from this problem, but the variation of radius and inertia affect the thread tension [12]. Author in [12] presents in her work a study, which is relative to the modelling and the identification of the parameters of a Web Winding System of a reversible mill. Modelling is based on the general laws of physics laws using the strip elasticity, frictions between strip and rolls and the flow of strip between two rolls. The main goal of this work is the determination of the strip tension in movement and the strip velocity in order to synthesize the coupling between variables. Because of the important variation of the radius and inertia of the rolls, the system dynamics change considerably during the winding process. Thus, the stability and performances of system are studied on different range of radius variation.

The suggested tension controller in [13] includes a rotating strand feeding device frictionally-engaging the strand and a variable drag force-applying device cooperating with the rotating strand feeding device for adding a predetermined tension to the strand as the strand is delivered downstream from the strand delivery mechanism.

There are many solutions and patents with such facilities [14, 2, 15]. In the papers [1, 2] author suggests a facility for tension force measuring. This facility is based mainly on mechanical solution. In the work [15], which studied automated electric drive for chemical thread production machines; the used winding mechanism provides the speed control of the driving motor basing on the tension force of the winding material.

In such machines, by using of multilever system with spring, the tension force of the winding material may be controlled and adjusted. The main disadvantage of such mechanisms is that it has sophisticated multilever system for adjusting the thread tension force. Therefore, it requires more frequent maintenance, and it does not give high quality winding material. Therefore, to avoid these disadvantages the following facility has been suggested. And the suggested facility may be used in thread winding drives, used in textile industry.

II. Construction of the Suggested Facility

The suggested facility (tension-force regulator) may be used in synthetic fiber production in textile industry. The main goal of this facility is getting high quality of the wound material and to use simple devices. This goal is achieved by using the shown in Fig.1 and Fig.2 system where:

1 - The winding material (the thread);
2 - Pulley;
3 - Lever;
4 - Drum;
5 - Light source;
6 - Blind (shutter);
7, 8 - Light receivers (photo-transistors);
9 - Tape (ribbon);
10, 11 - Ferromagnetic cores;

DOI: 01.IJEPE.4.2. 5

12, 13 - dc coils;
14 - The reference tension force spring;
15 - Fixing stop;
16 - Nut for adjusting;
17 - Adjusting bolt;
18 - Holes for light passage;
19 - The bobbin;
20 - Moveable carriage;
21 - The driving motor;
22 - Compacting roller;
23 - Motor shaft.

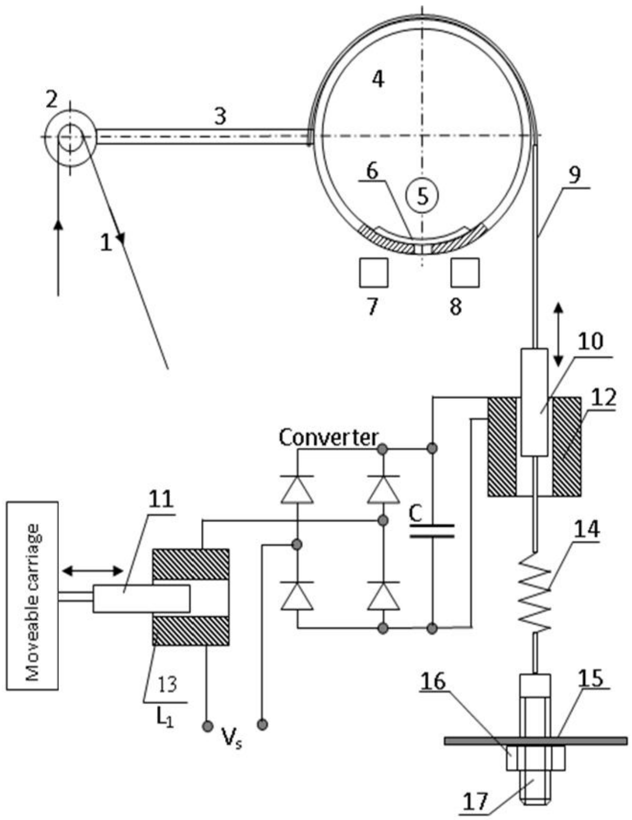

Fig. 1 The suggested sensor with accessories

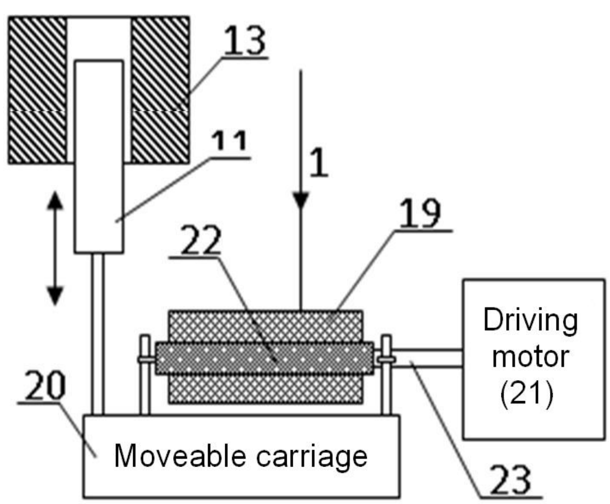

Fig. 2 The winding electric drive with the bobbin and the moveable carriage

The thread 1 moves through the low-friction pulley 2 on the lever 3 and wounded around the bobbin 19. The last one is fixed on the motor shaft 23. The coils 12 and 13 are not moveable. But the magnetic cores of both coils are moveable as shown in Fig. 1 and Fig. 2. The ferromagnetic core of the coil 13 is mechanically coupled with the carriage 20. The carriage 20 is rigid fixed to both the compacting roller 22 and the core of the coil 13 and the three elements move together during winding process. The output of the phototransistor is connected via amplifier to the motor controller as shown in Fig. 3.

III. Principle of Operation

Electrical motor 21 shown in Fig.3 winds the moving thread 1 round the bobbin 19. During winding process the thread experiences a tension force, which makes the lever 3 stationary in one certain position (in steady-state conditions). In this case the motor rotates at a constant speed, and the tension force of the thread is constant. In case of sudden changing in this tension force during winding process the lever 3 will change its position.

Assuming that the tension force has been increased then the lever goes downward and the pulley rotates counterclockwise. This will make more light flux pass through the hole to the phototransistor 7 and less light to the phototransistor 8. The output signal of these phototransistors is connected via amplifier, as shown in figure 3; to the controller in order to improve the motor speed (the motor slows down) to get the former desired tension force of the thread.

And in case of decreasing the tension force during winding process under the reference value (which may be set by the adjusting nut and spring) the same procedure occurs, but in this case the motor speeds up to get the desired former tension force.

In winding the thread round the bobbin at first the bobbin radius is small and so the compacting roller and the carriage are located in a certain position. The compacting roller in this case is close to bobbin axis. The magnetic core 11 of the coil 13 is mechanically coupled to the carriage. Thus, this magnetic core at first is located inside the coil 13.

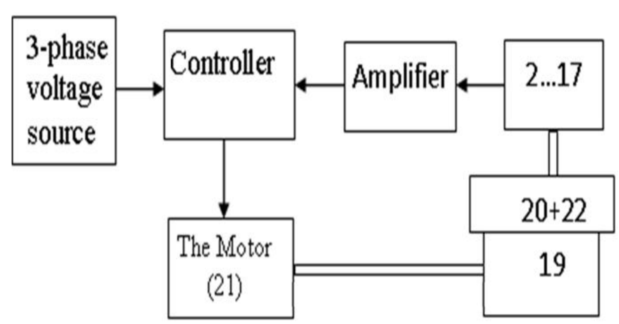

Fig. 3 Block diagram of the winding mechanism

Therefore, this coil has high self inductance, and so high reactance, and more than reactance of the coil 12, which core is partially located outside the coil. The two coils 12 and 13

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are connected in series, so the voltage of the ac source V_s is, mainly, applied to the coil 13. And a capacitor C, with suitable capacitance value, is used to get a resonant circuit or close to resonance. Thus the current in the coil 12 is very small. Therefore, no electromagnetic force is acting on the core 10. But during winding process the radius of the bobbin increases. And the tension force of the winding thread must be increased, a little, to get homogeneous density bobbin. The required increase of the tension force may be achieved automatically by the interacting of the coils, their cores and the lever.

As the bobbin radius increases during winding process the compacting roller and the carriage move farther from the bobbin axis. And the core 11 moves together with them, going out of the coil 13. This decreases the magnetic permeability for the magnetic flux of coil 13, which means that the self inductance and, so, the reactance of this coil decreases also. And finally the voltage across this coil decreases, while it increases on the other coil 12. That allows more current to pass through the coil 12 and gives more magnetomotive force.

And finally the core 10 will move more inside the coil 12. Therefore, the pulley 4 rotates clockwise and the lever 3 moves upward. This makes more light received by the phototransistor 8, which makes the driving motor to speed up. The lever moves back downward to the previous horizontal position with desired constant tension force of the thread. But higher than previous tension force. The new tension force overcomes and equals the larger tension force of both the magnetic coil 12 and the spring. This larger tension force occurs after the current increasing.

IV. Conclusion

In this paper has been designed an electromechanical system for regulation the tension force of winding fine materials. In winding fine strip material such a thread it is important to get homogeneous density of the wound package, to get high quality material in next processing of this package. In order to achieve this goal the designed facility controls the thread tension force during winding process and the driving motor speed. And it allows adjusting the tension force of the winding thread to the desired value, which is variable and depends on the radius of the package. This gives the required homogeneous density of the wound package material.

The suggested facility consists of simple components, and is provided by an adjusting element in order to set the tension force of winding material at the required reference value. The suggested facility may be used in thread winding drives, used in textile industry

References

[1] Addasi Emad Said, “Tension Force Regulator of Fine-winding Materials” International Journal of Electrical, Electronics and Computer Systems (IJEECS). Vol: 11 Issue: 01, November 2012.

[2] Addasi Emad Said, “An Electric Drive with A Special Measuring Disc” International Engineering Conference, Mutah University, Jordan, pp. 21-25. , 2004.

[3] Atanassov Nikola, Bedelev Borislav, “Rope-changing machine for mine winding plant” Patent number DE3325323, Application number DE19833325323 19830713, BG, 1985.

[4] Kashiwaba Tadao, “Setting and winding mechanism for tape-like laminate in laminator” Patent number US4709868, Application number US19860832041 19860221, JP, 1987.

[5] T. V. Silich, “Special features of treatment of cotton-polypropylene yarn in knitted fabric production” Fibre Chemistry journal, Vol. 43 (5), 372-375, DOI: 10.1007/s10692-012-9367-y, translated from Khimicheskie Volokna, 2011.

[6] V. G. Foman, K. N. Ushakova, “Brief review of domestic and foreign bobbin-winding equipment” Fibre Chemistry journal, machines and instruments, Vol. 32 (1), 79-82, DOI: 10.1007/BF02359206, translated from Khimicheskie Volokna, 2000.

[7] Soffel Michael, Wuestenberg Dieter, “Monitor to register material tension, during winding, directs an air stream from a jet between two support points, and the material movement is registered by a proximity sensor as a measurement of its tension” Patent number DE10148309, Application number DE20022048309 20010927, DE, 2003.

[8] Addasi E.S., “Modelling and simulation of AC electric drive control system with variable moment of inertia” International Journal of Modelling, Identification and Control (IJMIC), Vol. 14, No. 3, 2011.

[9] V.M. Ivanof, “Investigation into facilities of unfrictional automatic wind-up mechanism, Ph.D. Thesis, Kostrom, 1981.

[10] E.A. Tolkachov, and E.S. Addasi, “Facility for thread winding-up on a bobbin” Patent number 2009974, Application number 5030224/12, Russia, 1994.

[11] P. A. Bashashin, “High-speed friction bobbin carrier, Fibre Chemistry journal” machines and Equipment, Vol. 43 (5), 384-387, DOI: 10.1007/s10692-012-9370-3, translated from Khimicheskie Volokna, 2011.

[12] Nabila Rabbah, Bahloul Bensassi, “Modelling and simulation of MIMO non-linear systems web winding system of a reversible rolling mill” International journal of aytomation and control, Vol. 2, No. 4, pp. 459-469, 2008.

[13] Niederer, United States Patent, “Full-compensatiing tenstion controller” Patent No. US 6, 457,666 B1, 2002.

[14] Addasi Emad Said, “Transducer for Tenstion Force Measuring of Strip Materials” American Journal of Applied Sciences, Science Publications. New York, USA, Vol. 2, No. 1, pp. 400-402, 2005.

[15] Rbkin R.L., Fradin A.SH., “Automated Electric Drive for Synthetic Thread production” Mashinostroenya, Leningrad, Russia, pp. 116-118, 1982.

Biography

Emad Addasi was born in Jordan in 1966. He received the M. Sc. degree from Leningrad Institute of Water Transport (Russia) in 1990 in specialization Electric Drive and Industrial Plants Automation. His Ph.D. was on Elaboration and Investigation of Winding-up Motion with Magneto-electric Drive from Saint-Petersburg State University of Technology and Design (Russia) in 1994. His main research interests are electric machines, drives, transducers and control. He is an associate professor in Electrical Engineering Department at Faculty of Engineering in Tafila Technical University.

DOI: 01.IJEPE.4.2. 5